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CONNECTICUT RIVER

NEW HAMPSHIRE, VERMONT,
CONNECTICUT AND MASSACHUSETTS

CONFIDENTIAL

REVIEW OF REPORTS
ON
FLOOD CONTROL

APPENDIX - VOLUME 3

1940

SECTION 6 - LEVEES DETAILS & ESTIMATES
SECTION 7 - CHANNEL IMPROVEMENTS
SECTION 8 - PROFILES

HYDRAULICS
AND REPORTS

SECTION 6 REVISED
AGREE WITH MASTER COPY
LFD 10-17-45

UNITED STATES ENGINEER OFFICE
PROVIDENCE, RHODE ISLAND
FEBRUARY 28, 1940
Corrected to Oct. 15, 1940 (See attached sheets)

SECTION 6

LEVEES - DETAILS AND ESTIMATES

1. **EXISTING LEVEES.** - Levees for protection from floods have been constructed by various interests in the lower Connecticut River since the middle of the nineteenth century. There are no protective levees in the upper valley, in the States of New Hampshire and Vermont. The levees constructed to protect rural areas are principally to prevent erosion. Levees constructed to protect real estate and industrial developments were constructed, in general, to give protection against a flood of the magnitude of 1854, which, in the lower valley, was approximately the same height as the more recent flood of 1927. After the all-time record flood of 1936, which topped all existing levees and caused great losses, a number of existing levees were raised and enlarged by the Engineer Department, with local cooperation, as work relief projects in accordance with the Flood Control Act of 1936. Construction of levees at seven localities, as outlined in the comprehensive plan, was approved by the Flood Control Act of 1938. Portions of these levees have been completed. Detailed information pertaining to existing levee protection is given in the following table.

(Table on following page)

5. BASIS OF ESTIMATES. - Earth levees with a 10-foot crown width and side slopes of 1 vertical on 2-1/2 horizontal are provided, except where lack of space precludes their use, in which case reinforced flood walls of the cantilever type are used. River banks and earth fills, which are subject to scour by ice action or high velocities, are protected by riprap. Steel sheet-piling cut-offs are provided under concrete walls and earth fills that may be subject to high heads and which are constructed on permeable foundations that will permit a relatively high amount of seepage. Subsurface filter drains are proposed at the landside of high earth sections to insure adequate stability of the wall structure by maintaining a low saturation line, and at the landside toe of all concrete walls to prevent piping. In the design of provisions for adequate drainage of the protected areas during flood stages of the Connecticut River, the capacities of the pumping plants and drainage systems have been based on the following factors: amount of rainfall, intensity, and duration of storms; sanitary sewage based upon population intensities; seepage through and under levees; leakage of gates; and size of storage basins, if any. The costs of the levees were estimated upon designs which will provide the most economical and safe construction for a particular site.

6. COORDINATION WITH OTHER LOCAL PROJECTS. - In all cases effort has been made to determine plans for future construction under consideration by local interests, in order that any proposed levee construction can be adapted to a local improvement program, as long as the Federal expenditure for flood control is not increased and the integrity of the levee construction is protected.

7. UNIT PRICES. - Unit prices are based upon construction costs for similar types of work in New England and elsewhere and recent contract work in the District, particular use being made of data on various existing

levees, and drainage and pumping systems in the Connecticut Valley. Unit prices vary with the conditions, method of construction, and the availability and location of materials at each site.

8. CONTINGENCIES, ENGINEERING, AND OVERHEAD. - Contingencies are estimated at 20 percent to take account of possible variations in the subsurface conditions, flexibility in the design of the levees, and construction difficulties anticipated. Engineering and overhead are estimated at 15 percent of the construction costs.

9. RIGHTS-OF-WAY AND DAMAGES. - The estimates of costs of rights-of-way and the estimated damages which will accrue because of the acquisition of lands for the construction of levees are based upon information from local officials, upon assessed valuations, and upon field reconnaissance in accordance with generally accepted appraisal methods. Under the state laws properties are assessed at their fair market values, based on appraisals made every ten years. Damages to riparian rights have been classed as damages since the disposition of the rights by the individual owners can not be foretold prior to acquisition of rights-of-way. Legal, overhead, and general expenses have been estimated at 20 percent.

"Amount to complete" $303,000

is a conservative est. of

cost to U.S. as Keeney Lane

will cost $211,000 and

Bushnell 296,000

$507,000

Totals 5,756,000

303

cost to U.S. 6,059,000 in lieu of 5,900,000 in report.

Above change will cause incidental revision in report and appendix

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10. HARTFORD, CONNECTICUT.

a. General description. - A general description of the project is given in the body of the report. The items of work and their component costs are listed below. Their geographic limits are shown on Plate No. 95; typical sections are shown on Plate No. 96.

ITEM	STATUS	COST TO U.S. GOVT.	COST TO CITY OF HARTFORD	AMOUNT TO COMPLETE CONTRACT	TOTAL COST	REMARKS
1 to Ht. 4 and 7a	Completed	$1,381,000	$ 594,000	0	$1,975,000	
t.5 - 7b	Completed	920,000	958,000	0	1,878,000	Construction
lt.5 - 7b	Completed		453,000		453,000	Reconstruction of slide
lt. 6	Completed	2,817,000	531,000	0	3,348,000	
lt. 8	Nearly completed	435,000	0	3,000	438,000	
lt. 9	Completed	99,000	0	0	99,000	Temporary
~~lt. 10~~	Completed	50,000	0	0	50,000	Temporary
eney Lane mping Station	Under design	24,000	*	(a) 140,000	164,000	Permanent station
shnell Park mping Station	Under design	30,000	*	(a) 160,000	190,000	Permanent station
	TOTALS	$5,756,000	$2,542,000	$303,000	$8,601,000	

* City of Hartford will bear portion of total cost after construction is complete.

(a) To be constructed after the present war emergency.

walls providing the protection along

desires a grade for the general protection from 5 to 6 feet higher than that authorized, a 15-foot top width for earth levees, and a conduit instead of flood walls for the Park River. The city will bear the additional expense of such work.

c. Detailed description. - Items Ht.1, 2, 3, and 4 provide protection for the zone north of Memorial Bridge. Items Ht.1 and 2 have been completed by hired labor operations, and Items Ht.3 and 4 are under contract.

(1) Item Ht.1 involved the excavation and completion of the Meadow Brook diversion channel, and the placing of about 300,000 cubic yards of earth embankment and 145,000 square feet of steel sheet piling, at a total cost of $361,000.

(2) Item Ht.2 included the excavation of a cut-off trench and the placing of 136,000 square feet of steel sheet piling, at a cost of $154,000.

(3) Item Ht.3 is a pumping plant serving a drainage area of 1,340 acres. Construction involves 13,000 cubic yards of common excavation, placement of 3,000 square feet of steel sheet-piling and 3,325 cubic yards of reinforced concrete, construction of a superstructure, and installation of pumping equipment (furnished under separate contract), all at a total cost of $246,000.

(4) Item Ht.4 consists of the construction of an earth levee, complete with riprap protection, from Memorial Bridge north to Station 98, and from Station 158 to Station 162, the provision of steel sheet-piling from Memorial Bridge to Station 58 and from Station 159+63 to Station 161+30, the construction of two stop-log structures and the excavation of the Pumping Station storage pond. The principal quantities are 927,000 cubic yards of earth embankment, 197,000 square feet of steel sheet piling, 2,400 cubic yards of reinforced concrete, and 41,000 cubic yards of riprap protection, all at an estimated cost of $890,000.

(5) Item Ht.5, Memorial Bridge to 700 feet south of Park River, consists of construction of approximately 4,800 linear feet of concrete wall with steel sheet piling, a small levee, and necessary bank treatment.

(6) Item Ht.6, Park River Protection and Pumping Stations, consists of 300 feet of concrete conduit and 7,300 feet of concrete walls

along the Park River, and two pumping stations. One of these will be in Bushnell Park at Wells and Hudson Streets, with a drainage area of 300 acres and a capacity of 158 c.f.s; the other will be the Keeney Lane Pumping Station, with a drainage area of 256 acres and a capacity of 154 c.f.s. The cost of rebuilding and repairing the bridges crossing the Park River has not been included in the estimate, since this is an obligation of the locality.

(7) Item Ht.7a, Aviation Road north 900 feet, consists of the enlargement and repair of 900 feet of the existing Clark Dike, and is now being executed by hired labor. It involves placing approximately 32,000 cubic yards of embankment and 1,000 cubic yards of riprap, and a number of incidental drainage items, all at a total cost of $59,500. The City of Hartford's share is estimated at $24,500, giving a net cost to the United States of $35,000.

(8) Item Ht.7b, 700 feet south of Park River to 900 feet north of Aviation Road, consists of approximately 4000 feet of earth levee and 900 feet of concrete wall, including steel sheet-piling cut-off, and a pumping station of 25 c.f.s. capacity. This alinement includes protection for the South Meadows steam-electric station of the Hartford Electric Light Company, which originally was not included in the protection. The additional cost resulting from the change in alinement is estimated to be $252,000 over that of the original alinement. A small item of work remains to be completed in connection with the South Meadows levee. This consists of enlarging and raising by about 2 feet, 70 feet of levee between the railroad stop-log structure and high ground near Wethersfield Avenue. This work was deferred at the request of the City of Hartford pending a decision regarding a proposed boulevard expected to be constructed in the locality.

(9) Item Ht.8, South Meadows levee, Aviation Road to Wethersfield Avenue, was executed by hired labor. It included repair and enlargement of approximately 11,400 feet of the existing South Meadows levee, and was accomplished as a W.P.A. project at a total cost of $199,000.

d. Cost estimates. - The detailed cost estimates for those items now under design follow:

HARTFORD, CONNECTICUT

COST ESTIMATE - ITEM Ht.5

Memorial Bridge to 700 feet south of Park River

Item No.	Designation	Quantity		Unit Cost	Amount	Total
1	Preparation of site	3	acres	1,000	$ 3,000	
2	Excavation	23,100	cu.yd.	.25	5,775	
3	Steel sheet piling	115,120	sq.ft.	1.00	115,120	
4	Gravel	1,430	cu.yd.	2.00	2,860	
5	Backfill	11,470	" "	.75	8,603	
6	Tile drains, 12" V.C. pipe	4,930	lin.ft.	.75	3,698	
7	Concrete (incl. cement)	11,025	cu.yd.	16.50	181,912	
8	Steel reinforcement	1,102,500	lb.	.05	55,125	
9	Miscellaneous iron and steel	3,750	"	.10	375	
10	Topsoil	2,370	cu.yd.	.50	1,185	
11	Sodding and seeding	2.93	acres	350	1,026	
12	Timber for stop-log	20,000	F.B.M.	85	1,700	
						$ 380,379
	Contingencies 20%					76,621
						457,000
	Engineering and overhead 15%					68,000
	TOTAL					525,000

HARTFORD, CONNECTICUT

COST ESTIMATE - ITEM Ht. 6

Park River protection and pumping stations

Item No.	Designation	Quantity	Unit cost	Amount	Total
1	Stream diversion (including cofferdam and pumping)	Lump sum		$ 80,000	
2	Excavation (earth) (including sheeting)	100,000	cu.yd.	0.75	75,000
3	Excavation (rock)	22,200	" "	2.50	55,500
4	Embankment	8,050	" "	.10	805
5	Borrow excavation	85,200	" "	.40	34,080
6	Backfill	142,400	" "	.25	35,600
7	Rock protection	2,000	" "	6.00	12,000
8	Steel sheet-piling	69,505	sq.ft.	1.00	69,505
9	Concrete (including cement)	82,000	cu.yd.	12.00	984,000
10	Steel reinforcement	9,320,200	lb.	.05	466,010
11	Drainage features (including temporary care of existing open drains)	Lump sum		15,000	
12	Concrete piles	50,000	lin.ft.	1.75	87,500
13	Replacement of industrial track and related structures of power plant and cleaning up	Lump sum		10,000	
14	Support of buildings	Lump sum		25,000	
15	Pumping stations	2	130,000	260,000	
					$2,210,000
	Contingencies 20%				440,000
					2,650,000
	Engineering and overhead 15%				398,000
	Total				3,048,000

HARTFORD, CONNECTICUT

COST ESTIMATE - ITEM Ht.7b

700 feet south of Park River to 900 feet north of Aviation Road.
Includes Hartford Electric Light Company

Item No.	Designation	Quantity		Unit cost	Amount	Total
1	Preparation of site	5.5	acres	Lump sum	$ 880	
2	Stripping	10,603	cu.yd.	.50	5,300	
3	Common excavation	10,450	" "	.40	4,180	
4	Cut-off trench excavation	7,365	" "	.40	2,950	
5	Impervious borrow	40,436	" "	.65	26,280	
6	Pervious borrow	29,735	" "	.65	19,330	
7	Impervious embankment	40,436	" "	.15	6,060	
8	Pervious embankment	40,400	" "	.12	4,850	
9	Riprap, hand-placed	2,245	" "	5.00	11,230	
10	Remove and replace existing riprap	446	" "	4.50	2,010	
11	Steel sheet-piling	61,900	sq.ft.	1.00	61,900	
12	Gravel - bedding and filters	4,127	cu.yd.	2.00	8,250	
13	Gravel - top of levees	598	" "	2.00	1,200	
14	Backfill	6,400	" "	.75	4,800	
15	12" V.C. drains	2,950	lin.ft.	.65	1,920	
16	Concrete, Class A	2,860	cu.yd.	12.00	34,320	
17	Cement	3,930	bbl.	2.50	9,830	
18	Reinforcing steel	257,400	lb.	.05	12,870	
19	Miscellaneous iron and steel	2,600	"	.15	390	
20	Topsoil	5,680	cu.yd.	1.00	5,680	
21	Sodding and seeding	5.6	acres	5.00	2,800	
22	Cleanup			Lump sum	2,000	
23	Pumping station			Lump sum	30,000	
24	Concrete piling	1,040	lin.ft.	1.60	1,670	
25	Cofferdam and pumping	300	"	Lump sum	4,500	
						$265,200
	Contingencies 20%					53,040
						318,240
	Engineering and overhead 15%					47,760
	TOTAL					366,000

11. EAST HARTFORD, CONNECTICUT.

a. Description. - A general description of the project is given in the body of the report. The items of work and their component costs are listed below. Their geographic limits are shown on Plate No. 97; typical sections are shown on Plate No. 98.

Item of work and location	Present status	Estimated construction cost
East Hartford, Connecticut		Total $2,407,000
EH.1 - Levee, initial hired labor unit	Completed	24,000
EH.2 - Levee and wall, railroad south along Connecticut River	Under construction	743,000
EH.3 - Levee, Connecticut River to Swale	For future design	188,000
EH-4 - Levee, Swale up Hockanum River	" " "	413,000
EH.5a - Levee, north of New Haven Railroad	" " "	595,000
EH.6 - Pumping stations	" " "	444,000

(1) Item EH.1, a section of earth levee extending 400 feet north of Connecticut Boulevard, was completed by hired labor operations. The principal quantities were 9,000 cubic yards of excavation, 2,000 cubic yards of earth embankment, and 13 acres of clearing and grubbing, all at a total cost of $24,000.

(2) Item EH.2, consisting of an earth levee and a concrete flood wall from the railroad south along the Connecticut River, is now under construction by contract. The work consists of 6,600 feet of earth levee and 550 feet of concrete flood wall, involving 430,000 cubic yards of earth embankment, 39,000 cubic yards of excavation, 4,800 cubic yards of reinforced concrete, 125,000 square feet of steel sheet-piling, and the construction of the outlet works for the Cherry Street and Pitkin Street Pumping Stations and related drainage facilities, all at a total cost of $743,000.

(3) Item EH.3 is an earth levee extending 1,600 feet from the Connecticut River to the Swale, at a total estimated cost of $188,000.

4) Item EH.4 is a length of levee and wall extending from the Swale up the Hockanum River. It includes 5,100 feet of earth levee, 200 feet of concrete flood wall, one stop-log structure, and related drainage facilities, all at a total estimated cost of $413,000.

(5) Item EH.5a consists of a levee north of the New York, New Haven and Hartford Railroad. The principal items of work are 6,900 feet of earth levee, one stop-log structure, drainage facilities, and river bank treatment, all at a total estimated cost of $595,000.

(6) Item EH.6 consists of the construction of three pumping stations: Cherry Street (excluding outlet), 30 c.f.s.; Pitkin Street (excluding outlet), 45 c.f.s.; and at the south end of the Swale (including outlet and storage pond), 300 c.f.s.; all at a total estimated cost of $444,000.

b. Cost estimates. - The detailed cost estimates of those items for future design follow:

EAST HARTFORD, CONNECTICUT

COST ESTIMATE - ITEM EH.3

Connecticut River to Swale

Item No.	Designation	Quantity	Unit cost	Amount	Total
1	Preparation of site	4 acres	150.00	$ 600	
2	Care of water		Lump sum	500	
3	Excavation, common	14,000 cu.yd.	0.40	5,600	
4	Steel sheet-piling	25,700 sq.ft.	1.00	25,700	
5	Embankment	132,000 cu.yd.	0.65	85,800	
6	Riprap, hand-placed	1,500 " "	5.00	7,500	
7	Drainage system	1,700 lin.ft.	5.00	8,500	
8	Miscellaneous		Lump sum	2,200	
					$136,400
	Contingencies 20%				27,300
					163,700
	Engineering and overhead 15%				24,300
	TOTAL				$188,000

DEFINITE

EAST HARTFORD, CONNECTICUT

COST ESTIMATE - ITEM EH.4

Swale up Hockanum River

Item No.	Designation	Quantity	Unit cost	Amount	Total
1	Preparation of site	14 acres	150.00	$ 2,100	
2	Care of water		Lump sum	11,000	
3	Excavation, common	41,000 cu.yd.	0.50	20,500	
4	Embankment	268,000 " "	.59	158,100	
5	Steel sheet-piling	33,000 sq.ft.	1.00	33,000	
6	Concrete, reinforced	1,000 cu.yd.	15.00	15,000	
7	Steel reinforcement	95,000 lb.	.05	4,750	
8	Drainage system	8,300 lin.ft.	5.50	45,900	
9	Miscellaneous		Lump sum	9,100	
					$299,200
	Contingencies 20%				59,800
					359,000
	Engineering and overhead 15%				54,000
	TOTAL				413,000

OEL

EAST HARTFORD, CONNECTICUT

COST ESTIMATE - ITEM EH.5a

Levee, north of New Haven Railroad

Item No.	Designation	Quantity	Unit cost	Amount	Total
1	Preparation of site	24 acres	150.00	$ 3,600	
2	Care of water		Lump sum	1,500	
3	Excavation, common	48,000 cu.yd.	0.45	21,600	
4	Steel sheet-piling	40,600 sq.ft.	1.00	40,600	
5	Embankment	515,000 cu.yd.	0.40	206,000	
6	Riprap, hand-placed	14,500 " "	5.00	72,500	
7	Concrete, reinforced	500 " "	16.00	8,000	
8	Steel reinforcement	50,000 lb.	0.05	2,500	
9	Drainage system	6,000 lin.ft.	3.60	21,600	
10	Miscellaneous		Lump sum	27,300	
11	Bank protection		" "	26,400	
					$431,600
	Contingencies 20%				86,400
					518,000
	Engineering and overhead 15%				77,000
	TOTAL				595,000

EAST HARTFORD, CONNECTICUT

COST ESTIMATE - ITEM EH.6

Pumping stations

Item No.	Designation	Unit cost	Amount	Total
1	Cherry Street Station (excluding conduit)	Lump sum	$ 30,000	
2	Pitkin Street Station (excluding conduit)	" "	42,000	
3	Swale Station	" "	250,000	
				$322,000
	Contingencies 20%			64,400
				386,400
	Engineering and overhead 15%			57,600
	TOTAL			444,000

12. SPRINGFIELD, MASSACHUSETTS.

a. Description. - A general description of the project is given in the body of the report. The items of work and their component costs are listed below. Their geographic limits are shown on Plate No. 99; typical sections are shown on Plate No. 100.

Item of work and location	Present status	Estimated construction cost
Springfield, Massachusetts		Total $1,118,000
S.1 - Levee, hired labor unit above North End Bridge	Completed	6,000
S.2 - South End levee section	Under construction	235,000
S.3 - Mill River Conduit	Under construction	354,000
S.4 - Wall, North End Bridge to Chicopee line	Completed	325,000
S.5 - Wall, Chicopee line to high ground	Under construction	158,000
S.5a - Plainfield pumping station	Under construction	40,000

(1) Item S.1, consisting of earth levee construction from North End Bridge to Station 4+70, a total length of 380 feet, of which the principal quantity is 1,000 cubic yards of earth fill, was completed as a work relief project at a total cost of $6,000.

(2) Item S.2, South End levee section, consists of three sections of concrete wall and a length of earth levee. The wall units are: (1) from Elm Street and Columbus Avenue to high ground at Union Street, a total length of 1,790 feet, including reinforcement of the riverside wall of the United Electric Light Company plant; (2) from high ground at Gardner Street to Mill River, a total length of 1,220 feet; and (3) from Mill River to a point 300 feet north of South End Bridge, a total length of 1,660 feet. Earth levee will extend from this point to South End Bridge, a length of 330 feet. Five stop-log structures will be constructed. The principal quantities involved are 5,350 cubic yards of reinforced concrete and 67,000 square feet of steel

sheet-piling. The project is now being constructed under contract at a total cost of $235,000.

(3) Item S.3, Mill River Conduit, consists of a reinforced concrete conduit and walls extending approximately 1,665 feet upstream from the Connecticut River to an existing dam. The project is now being constructed at an estimated cost of $354,000.

(4) Item S.4, 5,700 linear feet of concrete flood wall and river bank improvement, extends from about 500 feet north of the North End Bridge to the Chicopee city line. The principal quantities involved are 8,260 cubic yards of reinforced concrete, about 20,000 cubic yards of excavation and backfill, 1,000 cubic yards of riprap, and 104,500 square feet of steel sheet-piling. The project is now being constructed under contract at a total cost of $325,000.

(5) Item S.5, extending north from the Chicopee city line to high ground, consists of two sections of concrete flood wall and river bank protection: (1) from Chicopee city line to the south end of the existing flood wall at the Springfield Rendering Plant, a total length of 2,200 feet, and (2) from the north end of the existing flood wall at the Springfield Rendering Plant to high ground at the Boston and Maine Railroad, a total length of 330 feet. The principal quantities involved are 2,770 cubic yards of reinforced concrete, about 16,000 cubic yards of excavation, 3,800 cubic yards of hand-placed riprap, and 37,000 square feet of steel sheet-piling. The project is now being constructed under contract at a total cost of $158,000.

(6) Item S.5a, is a pumping plant located near Plainfield Street, Chicopee, serving a drainage area of 30 acres. The project is now being constructed under contract at a total cost of $40,000.

13. WEST SPRINGFIELD, MASSACHUSETTS

a. Description. - A general description of the project is given in the body of the report. The items of work and their component costs are listed below. Their geographic limits are shown on Plate 101; typical sections are shown on Plate No. 102.

Item of work and location	Present status	Estimated construction cost
West Springfield, Massachusetts	Total	$1,502,000
WS.1 - Levee and wall above Agawam Bridge	Completed	177,000
WS.2 - Levee, Memorial Bridge to Sta. 32	Completed	120,000
WS.3 - Levee, Sta. 32 to Sta. 56+87	Under construction	144,000
WS.4 - Levee, Sta. 56+87 to Agawam Bridge	For future design	305,000
WS.5 - Levee and wall, North End Bridge to Memorial Bridge	Under construction	325,000
WS.6 - Levee and wall, north of North End Bridge	Completed	97,000
WS.7 - Pumping stations	For future design	334,000

(1) Item WS.1 is a levee and wall extending from the Agawam Bridge upstream along the Westfield River to high ground, and consists of approximately 3,200 feet of earth levee enlargement and 600 feet of new concrete flood wall. The principal quantities involved are 82,000 cubic yards of embankment, 755 cubic yards of reinforced concrete, 9,400 square feet of steel sheet-piling, and 8,000 cubic yards of hand-placed riprap. The project was constructed as a hired labor job at a cost of $177,000.

(2) Item WS.2 consists of 3,030 feet of earth levee enlargement extending from the Memorial Bridge to Station 32. The principal quantities are 32,000 cubic yards of earth fill, 29,100 square feet of steel sheet-piling, 1,700 cubic yards of rock fill, and 1,300 cubic yards of hand-placed riprap. The project was constructed under contract at a total cost of $120,000.

(3) Item WS.3 consists of 2,487 linear feet of earth levee enlargement along the Westfield River, between Stations 32 and 56+87.

This project is under construction at an estimated cost of $144,000.

(4) Item WS.4 consists of foundation treatment for approximately 6,100 linear feet of existing levee along the Westfield River, from Station 56+87 to the Agawam Bridge.

(5) Item WS.5 consists of earth levee enlargement, construction of reinforced concrete flood walls, repairs of existing stop-log structures and concrete walls, and river bank improvement between the North End Bridge and the Memorial Bridge. The total length of earth levee is approximately 5,000 feet, and of concrete walls 1,320 linear feet. The project is now being constructed as a hired labor job at an estimated cost of $325,000.

(6) Item WS.6 includes 410 linear feet of reinforced concrete flood wall and 2,400 linear feet of river bank improvement, north of North End Bridge. The principal quantities are 235 cubic yards of reinforced concrete, 6,000 cubic yards of excavation, 8,000 cubic yards of rock fill, and 3,500 cubic yards of hand-placed riprap. The item was constructed as a work relief project at a cost of $97,000.

(7) Item WS.7 includes construction of three pumping stations. Each involves a substructure, superstructure, equipment and installation, and an outlet conduit. The stations are located (1) at Warren Street, north of North End Bridge, serving a drainage area of 500 acres; (2) at Bridge Street, between North End Bridge and Memorial Bridge, serving a drainage area of 380 acres; and (3) at Circuit Avenue on the Westfield River, serving a drainage area of 585 acres. The latter station will be located at the Oxbow pond, which will be used as a storage pond.

b. Cost estimates. - The detailed cost estimates for these items under design and future design follows:

WEST SPRINGFIELD, MASSACHUSETTS

COST ESTIMATE - ITEM WS.7

Pumping stations

Item No.	Designation	Unit cost	Amount	Total
1	Warren Street Station (210 c.f.s. for equipment,) (280 c.f.s. for building)	Lump sum	$116,400	
2	Bridge Street Station (150 c.f.s. for equipment,) (200 c.f.s. for building)	Lump sum	94,000	
3	Ox Bow Station (30 c.f.s. for equipment) (and building)	Lump sum	31,600	
				$242,000
	Contingencies 20%			48,400
				290,400
	Engineering and overhead 15%			43,600
	TOTAL			334,000

14. CHICOPEE, MASSACHUSETTS

a. Description. - A general description of the project is given in the body of the report. The items of work and their component costs are listed below. Their geographic limits are shown on Plate No. 103; typical sections are shown on Plate No. 104.

Item of work and location	Present status	Estimated construction cost
Chicopee, Massachusetts	Total	$2,188,000
C.1 - Levee, initial hired labor unit	Completed	90,000
C.2 - Levee, north of Chicopee River	Under construction	340,000
C.3a - Levee and wall, south bank of Chicopee River, west of railroad - Hired labor	Under construction	189,000
C.3b - Levee and wall, south bank of Chicopee River, east of railroad - Contract	Under design	509,000
C.4 - Levee, Willimansett Section	Under construction	42,000
C.5 - Pumping stations	Under design	1,018,000

(1) Item C.1 consists of an earth levee from Station 107+43 to Station 152+31, and was completed by hired labor. The principal items of work consisted of the removal of Ames Sword Company Dam on the Chicopee River, damaged by the flood of 1938, and the placing of approximately 66,000 cubic yards of earth embankment and 4,500 linear feet of rock toe drains at a total cost of $90,000.

(2) Item C.2 is an earth levee north of the Chicopee River, now under construction by contract. It extends from Station 0 to Station 202+40, except the section between Stations 107+43 and 152+31, which is included in Item C.1. The principal items are approximately 285,000 cubic yards of earth embankment, approximately 10,800 linear feet of rock toe drain, approximately 7,800 cubic yards of hand-placed riprap for bank protection, one stop-log structure, and the conduit for a proposed pumping plant, all at a total cost of $340,000.

(3) Item C.3a is an earth levee and concrete wall on the south bank of the Chicopee River, west of the railroad. It is now being constructed by hired labor operations and consisted of approximately 575 feet of concrete wall, 1,050 feet of earth levee, and one stop-log structure, and one pumping station with a pumping capacity of 10 c.f.s.

(4) Item C.3b is a levee and wall on the south bank of the Chicopee River, east of the railroad, consisting of approximately 250 feet of earth levee, 2,600 feet of concrete wall, six tailrace gates and gate structures, and one stop-log structure.

(5) Item C.4, the Willimansett section, consists of approximately 600 feet of earth levee, relocation of Willimansett Brook Channel, and one stop-log structure. This project is now being constructed by hired labor operations at an estimated cost of $42,000.

(6) Item C.5 includes seven pumping stations, all to be constructed at an estimated cost of $988,000, and having locations and approximate pumping capacities as follows:

Pumping Station	Approx. Capacity
Charbonneau Terrace	115 c.f.s.
Call Street	150 "
Jones Ferry	300 "
Paderowski	130 "
Bertha Avenue	100 "
Station No. 6 (South Bank)	10 "
" " 7 " "	63 "
" " 8 " "	31 "

The construction of each pumping station includes the substructure and superstructure, the mechanical equipment and installation, and the outlet conduit. The Bertha Avenue pumping station will be provided with a small storage reservoir.

b. Cost estimates. - The detailed cost estimates for those items under design follow:

CHICOPEE, MASSACHUSETTS

COST ESTIMATE - ITEM C.3b

South bank of Chicopee River, east of railroad - Contract

Item No.	Designation	Quantity	Unit Cost	Amount	Total
1	Preparation of site	3 acres	2,000	$ 6,000	
2	Stripping	1,130 cu.yd.	.50	565	
3	Common excavation, general	20,370 " "	.25	5,092	
4	Impervious borrow excavation	3,560 " "	.30	1,068	
5	Random borrow excavation	4,350 " "	.30	1,305	
6	Pervious borrow excavation	3,360 " "	.40	1,344	
7	Steel sheet piling	19,000 sq.ft.	1.00	19,000	
8	Impervious fill, placing and rolling	3,560 cu.yd.	.20	712	
9	Pervious and random fill, placing and rolling	7,710 " "	.12	925	
10	Gravel bedding	1,340 " "	2.00	2,680	
11	Compacted backfill	14,530 " "	.75	10,898	
12	Riprap - hand-placed	870 " "	5.00	4,350	
13	Crushed stone drains	500 " "	2.50	1,250	
14	Cement	13,060 bbl.	2.50	32,650	
15	Concrete walls	9,674 cu.yd.	12.00	116,068	
16	Steel reinforcement	967,400 lb.	.05	48,370	
17	Topsoil on embankment	502 cu.yd.	1.00	502	
18	Sodding and seeding	.36 acre	350.00	126	
19	Gravel for top of levee	100 cu.yd.	2.00	200	
20	Stop-log (Depot Street)		Lump sum	10,000	
21	Rock excavation	2,000 cu.yd.	3.00	6,000	
22	Tailrace gate structures				
	#1 (Complete)(1 gate at 44 sq.ft.)		Lump sum	3,000	
	#2 (Complete)(1 gate at 57 sq.ft.)		" "	8,900	
	#3 (Complete)(1 gate at 252 sq.ft.)		" "	15,300	
	#4 (Complete)(3 gates at 260 sq.ft.)		" "	60,100	
23	18-inch V.C. pipe	1,000 lin.ft.	1.50	1,500	
24	24-inch V.C. pipe	1,770 " "	3.00	5,310	
25	Cleaning up		Lump sum	700	
					$363,215
	Contingencies 20%				73,783
					442,698
	Engineering and overhead 15%				66,302
	TOTAL				509,000

CHICOPEE, MASSACHUSETTS

COST ESTIMATE - ITEM C.5

Pumping stations

Item No.	Designation	Quantity	Unit cost	Amount	Total
1	Charbonneau Terrace Pumping Station				
	Concrete	110 cu.yd.	22.00	$ 2,420	
	Excavation	700 " "	.25	175	
	Backfill	550 " "	.40	220	
	Pumping station (115 c.f.s)		Lump sum	117,700	
	Total				$ 120,515
2	Call Street Pumping Station				
	Concrete	120 cu.yd.	22.00	2,640	
	Excavation	1,200 " "	.25	300	
	Backfill	1,000 " "	.40	400	
	Dike demolition and replacement	50 " "	.70	35	
	Pumping station (150 c.f.s.)		Lump sum	103,300	
	Total				106,675
3	Jones Ferry Pumping Station				
	Concrete	180 cu.yd.	22.00	3,960	
	Excavation	1,300 " "	.25	325	
	Backfill	900 " "	.40	360	
	Dike demolition and replacement	1,300 " "	.70	910	
	Pumping station (300 c.f.s)		Lump sum	175,000	
	Total				180,550
4	Paderewski Pumping Station				
	Concrete	160 cu.yd.	22.00	3,520	
	Excavation	1,400 " "	.25	350	
	Backfill	1,100 " "	.40	440	
	Dike demolition and replacement	250 " "	.70	175	
	Pumping station (130 c.f.s.)		Lump sum	103,300	
	Total				107,785
5	Bertha Avenue Pumping Station (100 c.f.s.)				85,000
6	Pumping Station No. 6 (West Station on South Bank) (10 c.f.s.)				22,000
7	Pumping Station No. 7 (Central " " " ") (63 ")				70,000
8	Pumping Station No. 8 (East " " " ") (31 ")				45,000
					737,500
	Contingencies 20%				147,500
					885,000
	Engineering and overhead 15%				133,000
	TOTAL				1,018,000

15. HOLYOKE, MASSACHUSETTS.

a. Description. - A general description of the project is given in the body of the report. The items of work and their component costs are listed below. Their geographic limits are shown on Plate No. 105; typical sections are shown on Plate No. 106.

Item of work and location	Present status	Estimated construction cost
Holyoke, Massachusetts	Total	$2,713,000
Hl.1 - Wall, initial hired labor unit	Completed	82,000
Hl.2 - Wall and pumping stations, north section	Under construction	1,186,000
Hl.2a - Pumping equipment	Under construction	82,000
Hl.3 - Wall and pumping stations, south section	Under design	1,363,000

(1) Item Hl.1 consists of a concrete flood wall extending from the Holyoke Water Power Company spillway 630 feet downstream. The principal quantities are 1,600 cubic yards of excavation, 1,740 cubic yards of reinforced concrete, and related drainage facilities. It was completed as a work relief project at a total cost of $82,000.

(2) Item Hl.2 consists of three sections of concrete flood wall and earth levee, having a total length of 5,500 feet, and four pumping stations. The first section, 1,400 feet of concrete flood wall, extends from the initial unit, Hl.1, along the north bank of the Holyoke No. 2 Wasteway to high ground on the west side of the Holyoke No. 2 Overflow. It has one pumping station of 62 c.f.s. capacity, serving a drainage area of 8 acres. The second section, 1,300 feet of concrete flood wall, extends from high ground on the east side of the No. 2 Overflow along the south bank of the No. 2 Wasteway to high ground at the County Bridge. It has one pumping station of 62 c.f.s. capacity, serving a drainage area of 7 acres. The third section, 2,400 feet of concrete

flood wall and 400 feet of earth levee, extends from high ground at the County Bridge downstream to high ground near Mosher Street. It has two pumping stations of 78 c.f.s. total capacity, serving a drainage area of 25 acres. The principal quantities involved are 62,000 cubic yards of earth and rock excavation, 21,900 cubic yards of reinforced concrete, 136,000 square feet of steel sheet-piling, 5,200 cubic yards of earth embankment, five stop-log structures, nine tailrace structures, related drainage facilities, four pumping stations, and installation of equipment. The project is now being constructed under contract at a total cost of $1,186,000.

(3) Item H1.2a, pumping equipment, includes the supplying of the necessary pumping units to the general contractor for Item H1.2, at a total cost of $82,000.

(4) Item H1.3 consists of three sections of concrete flood wall having a total length of 11,100 feet. The first section is 3,100 feet long and extends from high ground near Appleton Street downstream to the No. 4 Wasteway, and along the bank of the No. 4 Wasteway and the Third Level Canal to high ground at Cabot Street. It has one pumping station of 67 c.f.s. capacity, serving a drainage area of 18 acres. The second section is 3,200 feet long and extends along the landside bank of the Third Level Canal from high ground at Cabot Street to high ground at Main Street. It has one pumping station of 111 c.f.s. capacity, serving a drainage area of 72 acres. The third section is 4,800 feet long and extends from the existing concrete flood wall near Main Street along the bank of the Third Level Canal to the No. 4 Wasteway and downstream to the existing Springdale levee. It has one pumping station of 89 c.f.s. capacity, serving a drainage area of 19 acres. The principal quantities involved are 50,000 cubic yards of earth and rock excavation, 17,800 cubic yards of reinforced concrete, 255,000 square feet of steel sheet-piling,

eight stop-log structures, eight tailrace structures, related drainage facilities, and three pumping stations, including equipment. The total estimated cost of this project is $1,363,000.

b. Cost estimate. - The detailed cost estimate for the item now under design follows:

16. NORTHAMPTON, MASSACHUSETTS.

a. Description. - A general description of the project is given in the body of the report. The items of work and their component costs are listed below. Their geographic limits are shown on Plate No. 107; typical sections shown on Plate No. 108.

Item of work and location	Present status	Estimated construction cost
Northampton, Massachusetts	Total	$1,248,000
N.1 - Levee, initial hired labor unit	Completed	8,000
N.2 - Connecticut River levee	Under construction	232,000
N.3a - Diversion Canal, hired labor	Completed	106,000
N.3b - Diversion Canal, bridge and drop structure	Under construction	301,000
N.3c - Diversion Canal riprap	Completed	100,000
N.3d - Levee along Mill River, hired labor	Under construction	177,000
N.4 - Pumping station plus closure section of levee along Connecticut River	Under construction	324,000

(1) Item N.1, initial unit, consisting of the foundation preparation of an earth levee between Stations 6+50 and 14, was completed by hired labor operation. The principal items of work consisted of 3,500 cubic yards of stripping, 1,750 cubic yards of cut-off excavation, and the placing of 2,600 cubic yards of earth embankment, at a total cost of $8,000.

(2) Item N.2, Connecticut River levee, consisting of an earth levee between Stations 0 and 49+30, is now under construction by contract. The principal items including placing 254,000 cubic yards of earth embankment, 2,600 cubic yards of hand-placed riprap, 7,300 square feet of steel sheet-piling, and two reinforced concrete stop-log structures, at a total cost of $232,000.

(3) Item N.3a, the Diversion Canal between Stations C 1+50 and C 28+07, and between Stations C 35 and C 106, was completed by hired

labor operations. The principal item of work was the excavation of 230,000 cubic yards of material at a total cost of 106,000.

(4) Item E.3b, the Diversion Canal bridge and drop structure, is now under construction by contract. The item consists of excavation of the diversion canal between Stations C 28+07 and C 35, the construction of a bridge and drop structure, and 2,250 feet of highway relocation. The principal items of work include 75,600 cubic yards of excavation, 14,000 square feet of steel sheet-piling, 28,000 linear feet of timber piles, 5,600 cubic yards of reinforced concrete, and the relocation of roads, all at a total cost of $301,000.

(5) Item E.3c, Diversion Canal riprapping between Stations C 1+50 and C 28+07, was constructed under contract at a total cost of $97,000. The principal item was 14,300 cubic yards of hand-placed riprap along the upper portion of the canal.

(6) Item E.3d, the levee along the Mill River, is now being constructed by hired labor operations. It involves 1,900 feet of earth levee, 500 feet of concrete wall, one small concrete bridge, and one stop-log structure. The principal items are 361,000 cubic yards of earth embankment, 33,000 square feet of steel sheet-piling, 4,400 cubic yards of hand-placed riprap, and 1,400 cubic yards of reinforced concrete for the walls, bridge, and stop-log structure, all at an estimated cost of $177,000.

(7) Item E.4 is a pumping station plus the closure section of earth levee approximately 350 feet long along the Connecticut River. The drainage area served by the pumping station is 770 acres, and the ultimate pumping capacity is 300 c.f.s. The principal construction items for the pumping station are the substructure, superstructure, pumping equipment, and outlet conduit. This project is under construction at a total estimated cost of $324,000.

17. SPRINGDALE, MASSACHUSETTS.

a. Description. - Springdale is the southern section of the City of Holyoke, located on the right or west bank of the Connecticut River. It is largely a residential and mercantile section of a suburban nature. The entire Springdale area, with the exception of high ground at the extreme southern end, has been seriously affected by past floods. This area comprises Main Street and its mercantile outlets, three important industrial plants, and several residential streets.

b. The existing levee. - Following the flood of November 1927 a levee was built by the City of Holyoke extending from high ground near Day Street northward for 4,600 feet along the river bank and protecting an area of 122 acres, including three large factories, apartment buildings, stores, several homes, and a playground. This levee was overtopped in 1936 and a section of it was destroyed. It was repaired as a work relief project by local interests. This levee was seriously threatened during the flood of September 1938 when the water came within only one foot of its top. The levee as now built consists of an impervious homogeneous section of class 9 and 11 material with no toe drain. It is very poorly compacted and subject to cracking and sloughing at the inside toe during floods. The foundation consists of fine saturated sand in a loose state of compaction. These conditions render the levee unstable during floods and unreliable as protection for the area. This levee would join and form a continuous part of the protection authorized from Appleton Street south, for the southern area of Holyoke subject to flooding.

c. Flood losses. - The Springdale area of Holyoke was severely inundated by the flood of November 1927 and damaged to the extent of approximately $70,000 direct losses. The floods of March 1936 topped the levee which had been erected after the flood of November 1927 and resulted in direct losses of $312,800 and indirect losses of approximately the same

amount. After the flood of March 1936 the levee was again raised and, although the area was not flooded in September 1938, over 500 families evacuated their homes because of the hazardous and weakened condition of the levee, as well as flooding of cellars caused by failure of the pumping plant. In spite of the fact that the present levee afforded protection during the flood of September 1938, many lower floors and basements remain unoccupied and the value of industrial and residential property remains depressed as a result of general lack of confidence and fear of future flooding. The average annual benefits are estimated as $40,400.

d. Plan of improvement. - It is proposed to rebuild the Springdale Levee, following the existing alinement and raising the grade to that of the existing levee at Holyoke to which the Springdale Levee ties into at its northern end. The continuity of the improved earth levee will be broken only by a concrete gate structure, a pumping station, and concrete wing walls at the Berkshire Street sewer. The alinement of the levee is shown on Plate No. 109; typical sections are shown on Plate No. 110.

(1) Subsurface investigations. - Numerous test holes were driven along the existing levee to determine the condition of the underlying soil. The results of these investigations are shown on Plate No. 110, and indicate the need of a continuous steel sheet-piling cut-off to prevent the serious piping and seepage that the levee has been subjected to during past floods.

(2) Embankment. - The existing embankment will be improved with additional fill on the landside slope, and an impervious blanket on the riverside slope. There will be a crown 10 feet wide and the landside slope will be 1 vertical on 2-1/2 horizontal. The fill will be obtained locally and will consist of a well-compacted sandy clay well

suited for this type of structure. The final grade will be about 2 feet higher than that of the existing levee.

(3) Concrete walls and structures. - The concrete walls, which constitute protection between the gate and pumping station structure and the earth embankment, will vary from 12 feet to 32 feet in height and will be of cantilever design with landside counterforts where necessary. The gate structure and pumping station will be of reinforced concrete designed to match the similar structures now being built for the Holyoke Levee.

(4) Riprap. - Existing river currents and the small amount of foreshore indicate the need of riprap along the entire levee and it has been included in the design.

(5) Drainage and pumping. - The existing Berkshire Street sewer is a concrete pipe 10 feet in diameter and approximately 1,200 feet long, laid normal to the Connecticut River. It is impracticable to attempt its use as a pressure conduit and consequently it will be provided with a discharge gate and pumping station. A concrete pipe 4 feet in diameter will be laid along the landside of the levee from the existing Springdale pumping station to the Berkshire Street sewer at the gate structure. The Springdale pumping station will continue its operation, with any flow in excess of its capacity being taken care of by the proposed pumping station at the Berkshire Street sewer outlet.

(6) Basis of annual cost. - The Federal interest rate is 3-1/2 percent and amortization is 3-1/2 percent compounded annually. Non-Federal rates are 4-1/2 percent for each of the above items. Federal annual costs include interest and amortization of the total Federal investment. The total Federal investment includes the construction costs of the levee and pumping station. The non-Federal annual costs include, in addition to interest and amortization of the non-Federal investment,

tax loss computed at 4 percent per annum. The annual expenditure for operation and maintenance of the levee projects also will be borne by non-Federal interests. The total non-Federal investment would include the cost of lands, damages, and rights-of-way, the cost of relocation of a railroad siding, and the construction of drainage facilities. All costs would be amortized over a period of 50 years, except the pumping plant and equipment which would be amortized in 20 years. Maintenance and operation costs have been computed at 1 percent of the cost of the concrete and 3 percent of the cost of the pumping station. A lump sum has been added for maintenance of the embankment and other general expenses.

e. Cost estimate. - The estimated total and annual costs of the proposed plan follows.

SPRINGDALE (HOLYOKE), MASSACHUSETTS

ANNUAL COST ESTIMATE

Item No.	Item	Quantity Unit	Unit cost	Cost	Total cost
6.	Total annual cost				
	(a) Federal investment:				
	Levee construction	$207,200 by 1.38		$286,000	
	Pumping plant	63,000 by 1.38		87,000	
	Drainage and gates	13,000 by 1.38		18,000	
	Total Federal investment			391,000	
	(b) Federal annual charges				
	Interest $391,000 by 0.035			13,700	
	Amortization of obsolescence and depreciation:				
	Fixed parts $207,200 by 1.38 by .0076			2,180	
	Movable parts 76,000 by 1.38 by .0354			3,710	
	Total Federal annual charges				$19,590
	(c) Non-Federal investment				
	Land and damage	15,000 by 1.20		18,000	
	Drainage	24,000 by 1.38		33,000	
	Railroad relocation	5,000 by 1.21		6,000	
	Total non-Federal investment			57,000	
	(d) Non-Federal annual charges				
	Interest $57,000 by 0.045			2,560	
	Amortization of obsolescence and depreciation:				
	Land and damage	$15,000 by 1.20 by .0056		100	
	Drainage	24,000 by 1.38 by .0056		190	
	Railroad	5,000 by 1.21 by .0056		30	
	Tax loss on land $5,000* by 0.04			200	
	Maintenance and operation:				
	Embankment and general overhead			500	
	Operation and expendable supplies			500	
	Concrete $24,200 by 1.38 by .01			330	
	Pumping plant, gates, and machinery $71,000 by 1.38 by .03			2,940	
	Total non-Federal annual charges				7,350
	Total annual cost				26,940

*City of Holyoke is owner of land valued at $10,000

17-A. RIVERDALE (WEST SPRINGFIELD), MASSACHUSETTS.

a. Description. - Riverdale is the northern section of the town of West Springfield, located on the right or west bank of the Connecticut River, and opposite the city of Chicopee. The area is an alluvial plain, subject to frequent floods. On it are located 60 sets of buildings, several commercial establishments, and many large market gardens.

b. Flood losses. - Freshets cause frequent damage by erosion and silting, and occasional loss of market garden crops. Recent extraordinary floods have caused severe losses, and have affected the desirability and growth of the area. The flood of March 1936 caused a direct loss of $136,700 and indirect losses of approximately $55,000 in the area between Goldine and Bagg Brooks. The flood of September 1938 caused a direct loss of approximately $64,100. In addition, real estate valued at approximately $980,000 prior to 1936 has sustained depreciation losses of $170,000. Floods have prevented the natural growth of the area and the increase in value which should result from its desirable location, on a main highway and within two miles of the industrial centers of Chicopee, Holyoke, Springfield, and West Springfield.

c. Plan of improvement. - It is proposed to build an earth levee commencing at high ground on the south side of Goldine Brook. The alinement of the levee follows Goldine Brook for about 1000 feet to the bank of the Connecticut River, thence along the river about 9000 feet to Bagg Brook. The levee then follows Bagg Brook about 3000 feet to high ground. This plan is shown on Plate No. 110-A. Stop-log structures are provided at three points where highways cross the levee alinement. Two pumping stations are provided for the disposal of interior drainage.

(1) Subsurface investigations. - Numerous test holes have been driven along the proposed alinement to determine the characteristics

of the underlying soil. The results of these investigations are shown on Plate No. 110-A, and were considered in the design of the levee and its drainage.

(2) Embankment. - Typical sections of the proposed levee are shown on Plate No. 110-A. Side slopes of 1 vertical to 2-1/2 horizontal will be used. The crown will be 10 feet wide. There will be an impervious blanket on the riverside slope, faced with one foot of hand-placed riprap along the entire levee excepting the section along the bank of Bagg Brook. The embankment fill will be obtained locally and will consist of well-compacted sandy clay, well suited for this type of structure. Five feet of freeboard is incorporated in the design grades.

(3) Concrete structures. - Three reinforced concrete stop-log structures, varying from 6 to 12 feet high, will permit highways to pass through the levee. Wooden stop-logs and adequate removable braces will be supplied. Two concrete pumping stations will be built at the locations shown on Plate No. 110-A.

(4) Drainage and pumping. - The capacity of the pumping stations considers seepage, sewage, and storm run-off. The greatest single factor is storm run-off from the drainage area behind the levee, 640 acres for the large and 70 acres for the small pumping station.

(5) Basis of annual cost. - The Federal interest rate is 3-1/2 percent, and amortization is 3-1/2 percent compounded annually. Non-Federal rates are 4-1/2 percent for each of the above items. Federal annual costs include interest and amortization of the total Federal investment. The total Federal investment includes the construction costs of the levee, the stop-log structures, and the pumping stations. In addition to interest and amortization of the non-Federal investment, the non-Federal annual costs include the tax loss computed at 3 percent per annum on the assessed valuations, the maintenance and operation of the entire

protective works, and the cost of land, damage, and rights-of-way. All costs are amortized over a 50-year period, excepting the pumping stations and equipment, which are amortized over a 20-year period. Maintenance and operation costs have been entered as a reasonable lump sum.

d. Cost estimate. - The cost estimate and the annual costs of the proposed protective works are as follows:

RIVERDALE (WEST SPRINGFIELD), MASSACHUSETTS

ANNUAL COST ESTIMATE

Item No.	Item	Quantity	Unit	Unit cost	Cost	Total cost
6	Total annual cost					
	(a) Federal investment					
	Levee construction	$289,000 x 1.38			$399,000	
	Concrete	102,000 x 1.38			140,500	
	Machinery	36,000 x 1.38			49,500	
	Total Federal investment				589,000	
	(b) Federal annual charges					
	Interest	589,000 x 0.035			20,600	
	Amortization of obsolescence and depreciation:					
	Earthwork and general	289,000 x 1.38 x .0076			3,030	
	Concrete	102,000 x 1.38 x .0076			1,070	
	Machinery	36,000 x 1.38 x .0354			1,760	
	Total Federal annual charges					$ 26,460
	(c) Non-Federal investment					
	Land and damage				50,000	
	Total non-Federal investment				50,000	
	(d) Non-Federal annual charges					
	Interest	50,000 x 0.045			2,250	
	Amortization of obsolescence and depreciation:					
	Land and damage	50,000 x .0056			280	
	Tax loss on land	42,000 x .015			630	
	Maintenance and operation:					
	Embankment and general overhead				500	
	Operation and expendable supplies				500	
	Concrete	102,000 x 1.38 x 0.01			1,400	
	Pumping plants	36,000 x 1.38 x 0.03			1,480	
	Total non-Federal annual charges					7,040
	Total annual cost					33,500

18. SUMMARY OF COSTS. - The summary of the revised estimates, including modifications of alinement proposed in this report for local protection works now under way is given below:

Hartford, Connecticut	$5,824,000
East Hartford, Connecticut	2,407,000
Springfield, Massachusetts	1,118,000
West Springfield, Massachusetts	1,502,000
Chicopee, Massachusetts	2,188,000
Holyoke, Massachusetts	2,713,000
Northampton, Massachusetts	1,248,000
Total	17,000,000
Additional levees recommended herein*:	
Springdale (Holyoke), Massachusetts	$ 448,000
Riverdale (West Springfield), Massachusetts	639,000
Total	1,087,000

*Channel improvements are discussed in Section 7 of the Appendix.